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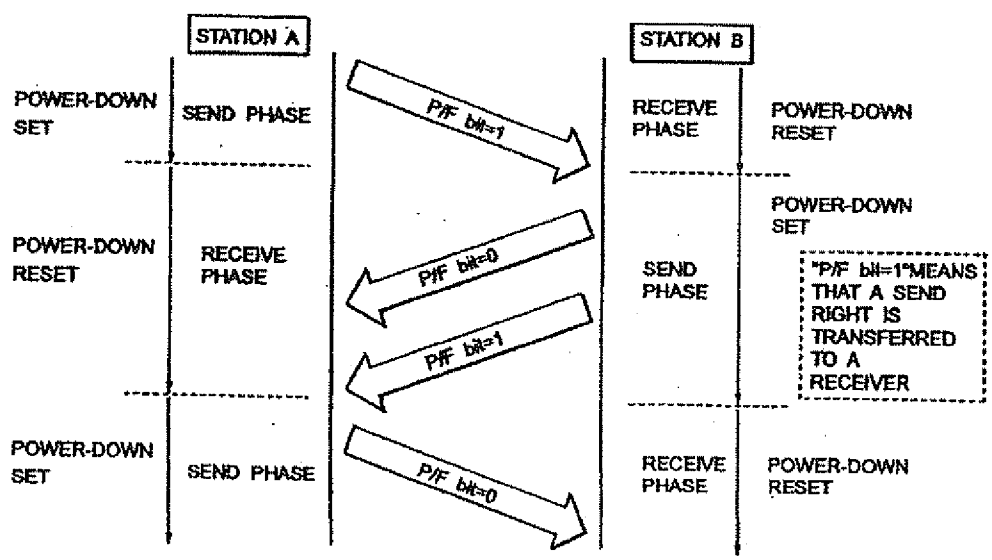
(54) Abstract Title

Half-duplex infra-red transceiver that deactivates its receiver when transmitting

(57) A data communication apparatus operable in half-duplex includes a transceiver, a detector for detecting an operation phase which is one of the send phase and the receive phase, and a controller controlling the transceiver such that the receiver is stopped functioning during the send phase. Preferably the transceiver is optical and operates in accordance with Standard IrDA (Infra red Data Association) protocals. Deactivating the receiver in this way saves power.

FIG. 1



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DATA COMMUNICATION METHOD AND APPARATUS

The present invention generally relates to data communication techniques and in particular to data communication method and apparatus which can reduce in power consumption.

Infrared (IR) communication technology is being employed in the field of a portable information device such as a mobile PC (personal computer) or a PDA (personal digital assistant) because IR transmitters and receivers can be built at relatively low cost and with small size and low power consumption suitable for battery-supported operation. To achieve bidirectional communication, IrDA (Infrared Data Association) protocol based on half-duplex operation is usually employed in IR communications because full-duplex operation must split the bandwidth between two directions, which is difficult for IR communication.

In general, an IR device having a light-emitting device, a light-receiving device and drivers thereof packaged therein is used to equip a portable information device with an IR interface. Since the portable information device is usually powered through a battery, the power consumption of the IR device is preferably as low as possible. Therefore, an IR device having power-saving function called power-down mode is usually

employed.

The light-emitting device of the IR device basically consumes power only when IR light is emitted while the light-receiving device consumes power at all times. Therefore, the power-down mode can be realized by stopping the function of driving the light-receiving device. The power-down mode is widely used in such a way that it is reset during IR communication, otherwise set.

There have been proposed various power-saving methods in the field of communications. Several examples will be described hereafter.

Japanese Patent Unexamined Publication No. 6-152518 discloses a network terminating device which can reduce the power consumption. More specifically, the network terminating device is provided with a power controller which stops power supplying to a part of a receiving circuit without impairment of starting control when a photodetector detects no receiving signal, that is, during a standby state. Therefore, the power consumption during standby can be reduced. In other words, it cannot reduce the power consumption during communication.

Japanese Patent Unexamined Publication No. 6-181593 discloses a radio transmitter having a photodetector and a transmitting circuit. When an ID code is set by using an IR remote control unit, the photodetector detects no receiving signal is supplied with power and the transmitting circuit is powered off. Contrarily, in the

case of normal communication mode, the transmitting circuit is powered on and the photodetector is powered off. In this manner, the power consumption is reduced. However, since the transmitting circuit is powered off when the ID is set, the power consumption during normal communication is not reduced.

Japanese Patent Unexamined Publication No. 6-216789 discloses a radio transmitter which controls a power supply circuit such that a light-receiving circuit is supplied with power only during a time period from when the radio transmitted is powered on to when first transmission is performed after powered on. However, the light-receiving circuit does not function as a receiver for bidirectional communication. Therefore, the power consumption during communication is not reduced.

Japanese Patent Unexamined Publication No. 8-8710 discloses an optical communication controller which is provided with a power controller dedicated to an optical transmitter. The optical transmitter is powered on when starting optical transmission and is powered off when the optical transmission is terminated. In this example, similarly, the power consumption during communication is not reduced.

An object of the present invention is to provide a data

communication method and apparatus which can achieve more reduction in power consumption.

According to the present invention, a data communication apparatus operable in half-duplex mode alternately switching between a send phase and a receive phase, includes a transceiver including a transmitter and a receiver; a detector for detecting an operation phase which is one of the send phase and the receive phase; and a controller controlling the transceiver such that the receiver is stopped functioning during the send phase.

The controller controls the transceiver in communication such that the receiver is not driven during the send phase but during the receive phase.

Preferably, when the detector detects a phase switch signal from one of sending data and received data, the controller switches the operation mode between the send phase and the receive phase. The phase switch signal may be a poll/final (P/F) bit.

According to another aspect of the present invention, a data communication method for exchanging data in half-duplex mode between a first terminal and a second terminal, includes the following steps. The first terminal having a first transceiver sends frames of data to the second terminal with setting a receiving function of the first transceiver to power-down mode during a send phase, switches the send phase to a receive phase when a final frame is sent to the second

terminal; and receives frames of data from the second terminal during the receive phase. The second terminal having a second transceiver receives the frames of data from the first terminal during the receive phase, switches the receive phase to the send phase when the final frame is received from the first terminal, and sends frames of data to the first terminal with setting a receiving function of the second transceiver to power-down mode during the send phase.

As described above, when operating in send phase, the receiving function is stopped. This allows power consumption in communication to reduce without impairing the communication function. Therefore, the battery life built in a battery-powered terminal such as a portable information terminal can be increased.

Another advantage can be obtained. Since the light-receiving function of an optical transceiver is stopped during the send phase, a so-called echo-back canceling effect can be automatically achieved. In general, the light-emitting part is adjacent to the light-receiving part within the optical transceiver. Therefore, the light emitted from the light-emitting device is partly incident back to the light-receiving device. To cancel such an echo-back component, the conventional communication apparatus needs the echo-back canceling function which is implemented with software or hardware. According to the present invention, there is no need to provide dedicated

hardware or software dedicated to the echo-back canceling function, resulting in simplified hardware and software configuration.

The invention will now be described merely by way of example with reference to the accompanying drawings wherein:

Fig. 1 is a sequence diagram showing an embodiment of a data communication method according to the present invention;

Fig. 2 is a diagram showing a frame format conforming to IrDA protocol for use in the embodiment of the present invention;

Fig. 3 is a block diagram showing an embodiment of a data communication apparatus according to the present invention;

Fig. 4 is a schematic block diagram showing a final frame detection system for explanation of frame checking operation in the embodiment of Fig. 3;

Fig. 5 is a flow chart showing a frame check operation of a processor in receive phase;

Fig. 6 is a flow chart showing a frame check operation of a processor in send phase; and

Fig. 7 is a block diagram showing another embodiment of a data communication apparatus according to the present invention.

According to the IrDA physical layer protocol, when at low data transmission rate, an asynchronous serial interface is employed, and when at high data transmission rate, a synchronous serial interface is employed. As a first embodiment of the present invention, the case of low data transmission rate at up to 115.2 kbps will be described hereafter.

As shown in Fig. 1, consider that stations A and B are communication with each other according to the IrDA protocol based on half-duplex operation. Data communication between the stations A and B is performed in frames conforming to the IrDA protocol. As described later, the P/F (poll/final) bit included in a frame is used to exchange the right to send between them.

If the station B has received a frame including P/F bit =1 from the station B, then the station B determines that the received frame is the final frame and therefore the station B must send a frame to the station A. In other words, the station B is changed from the receive phase to the send phase and therefore it is possible to stop power supplying to a receiver circuit, that is, the power-down mode is allowed to be set,

station B

resulting in reduced power consumption.

In the case where the station A is in receive phase, if the station A has received a frame including P/F bit = 0 from the station B, then the station A determines that the received frame is not the final frame and therefore the station A remains the current mode that is the power-down reset mode. If the station A has received a frame including P/F bit = 1 from the station B, then the station A is changed from the receive phase to the send phase and therefore the power-down mode is allowed to be set, resulting in reduced power consumption.

received phase.

In this manner, the P/F bit is used to exchange the right to send between the stations A and B to perform the power-down set/reset control at both stations. In other words, an operation state getting the right to send is called the send phase and an operation state losing the same is called the receive phase. The time period during which the right to send can be held at one station is determined by both sides prior to communication. The details will be described hereinafter.

Referring to Fig. 2, a frame conforming to the IrDA protocol is (n + m + 5) bytes long, where n and m are determined by the stations A and B prior to communication. The first n bytes of the frame are assigned to BOF code 21, which is followed by an address field of 1 byte and a control field of 1 byte.

= timeslots = time slots = n bytes

The address field 22 stores address information which is used to identify a terminal to communicate. The control field

23 stores frame type information which is used to identify the frame type. One bit of the control field 23 is assigned to the P/F bit 23a, which is used to exchange the right to send as described before. Here, if the P/F bit 23a is set to 1, then the frame thereof is the final frame. If the P/F bit 23a is reset to 0, then the frame thereof is not the final frame and therefore at least one frame follows.

An information field 24 for storing data to be transmitted is assigned to m bytes following the control field 23. The information field 24 is followed by a frame check sequence (FCS) field 25 of 2 bytes and an EOF code 26 of 1 byte. The FCS field 25 is used to determine whether the frame is acceptable. The EOF code 26 indicates the end of the frame. The FCS field 25 stores CRC (cyclic redundancy check) code. A receiving station performs a computation similar to the sending station on the complete frame and compares the computed CRC code with the received CRC code to determine whether a transmission error has occurred.

In the frame, an escape-effective range from the address field 22 to the FCS field 25 is provided to allow the same code as BOF code 21 or EOF code 26 to be included therein. In the case where the same code as BOF code 21 or EOF code 26 is to be sent within the escape-effective range, the same code to be sent is converted according to a predetermined bit operation to produce a code different from BOF code 21 or EOF code 26 and

then a specific code called escape code is positioned before the different code in the escape-effective range. At the receiving station, when detecting the escape code, the data following the escape code is converted using a similar bit operation to reproduce the original code. In this manner, any data can be used within the escape-effective range, which is called transparent control.

Referring to Fig. 3, an IR communication apparatus is provided with a processor (CPU) 1, which performs the communication control and the protocol processing as described later. The processor 1 is connected to a random access memory (RAM) 2, a read-only memory (ROM) 3, and an synchronous serial interface 4 through a system bus. The RAM 2 is used as a work area for communication protocol and a send/receive buffer. The ROM 3 stores IrDA stack program for protocol processing and other necessary control programs. The asynchronous serial interface 4 has a conversion function of converting data between serial and parallel.

The asynchronous serial interface 4 is connected to a modem 5 which has a conversion function of converting data between RZ code defined by IrDA protocol and NRZ code for the asynchronous serial interface 4. The modem 5 is connected to an IR device 6, which is provided with a light-emitting device and a light-receiving device. The light-emitting device is driven by a transmission driver to emit IR light modulated

depending on a transmission signal received from the modem 5. The light-receiving device is driven by a reception driver to convert incident IR light to an electrical signal and outputs it to the modem 5.

The IR device 6 is controlled by a power-down control signal PWDWN input from a universal port of the processor 1. More specifically, when PWDWN = 0, the light-receiving function of the IR device 6 is stopped operating by stopping power supplying to the reception driver for driving the light-receiving device (power-down set state). When PWDWN = 1, the light-receiving function of the IR device 6 is activated (power-down reset state). In this manner, the power-down control of the IR device 6 is performed by the processor 1 on which the communication program is running.

Referring to Fig. 4, a send/receive handler, an IrDA stack program for protocol processing, final frame detectors 9 and 10 are operating on the processor 1. When receiving an IR signal from another station, the asynchronous serial interface 4 outputs received parallel data to the processor 1 through the system bus. Therefore, the send/receive handler receives the received data and stores it onto the receive buffer 7 of the RAM 2. At this stage, the transparent control as described before is also performed. Subsequently, the stored frame data is sequentially read from the receive buffer 7 according to the IrDA stack program. The final frame detector 9 checks the P/F

bit 23a of the read frame data whether the read frame is the final frame. If it is the final frame, it is determined that the right to send is obtained and therefore the processor 1 controls the IR device 6 for power-down set mode.

On the other hand, a frame to be sent is assembled by the IrDA stack program and is then stored on the send buffer 8 of the RAM 2. Subsequently, the stored frame data is sequentially read from the send buffer 8 according to the send/receive handler. At this stage, the transparent control as described before is also performed. The final frame detector 10 checks the P/F bit 23a of the read frame data whether the read frame is the final frame. If it is the final frame, it is determined that the right to send is lost and therefore the processor 1 controls the IR device 6 for power-down reset mode.

OPERATION IN RECEIVE PHASE

As shown in Fig. 5, in the receive phase, the final frame detector 9 performs frame check to detect the final frame from data read out from the receive buffer 7.

After starting initialization and the frame check routine in the receive phase (step S101), the final frame detector 9 sequentially reads data in bytes from the receive buffer 7 until a code other than the n-byte BOF code 21 has been read from the receive buffer 7 (steps S102 and S103). When a code other than the n-byte BOF code 21 has been read (NO in step S103), the final frame detector 9 sequentially reads one-byte address

information and one-byte control information from the address field 22 and the control field 23 (step S104). Then, the final frame detector 9 determines whether the P/F bit 23a of the control field 23 is 1 (step S105). If the P/F bit = 0, a variable PF is set to 0 (step S106). If the P/F bit = 1, the variable PF is set to 1 (step S107).

Thereafter, the final frame detector 9 sequentially reads data in bytes from the receive buffer 7 until a code other than the one-byte EOF code 26 has been read from the receive buffer 7 (steps S108 and S109). When a code other than the one-byte EOF code 26 has been read (YES in step S109), the final frame detector 9 determines from the CRC code read from the FCS field 25 whether an error is present (step S110). If an error is detected (NO in step S110), that frame is discarded (step S111) and then control goes to the processing of the following frame. If no error is detected (YES in step S110), it is determined whether PF = 1 (step S112).

When PF = 1 (YES in step S112), it means that this frame is the final frame and therefore the processor 1 sets the power-down control signal PWDWN to 0 and changes the operation phase from the receive phase to the send phase (step S113). As described before, when PWDWN is set to 0, the IR device 6 is set to the power-down mode. Therefore, power is stopped supplying to the reception driver for driving the light-receiving device to stop the light-receiving function of the

IR device 6. The light-receiving function is not needed in the send phase. Thereafter, control exits from the frame check routine (step S114).

OPERATION IN SEND PHASE

As shown in Fig. 6, in the send phase, the final frame detector 10 performs frame check to detect the final frame from data read out from the send buffer 8.

After starting initialization and the frame check routine in the send phase (step S201), the final frame detector 10 sequentially reads data in bytes from the send buffer 8 until a code other than the n-byte BOF code 21 has been read from the send buffer 8 (steps S202 and S203). When a code other than the n-byte BOF code 21 has been read (NO in step S203), the final frame detector 10 sequentially reads one-byte address information and one-byte control information from the address field 22 and the control field 23 (step S204). Then, the final frame detector 10 determines whether the P/F bit 23a of the control field 23 is 1 (step S205). If the P/F bit = 0, a variable PF is set to 0 (step S206). If the P/F bit = 1, the variable PF is set to 1 (step S207).

Thereafter, the final frame detector 10 sequentially reads data in bytes from the send buffer 8 until a code other than the one-byte EOF code 26 has been read from the send buffer 8 (steps S208 and S209). When a code other than the one-byte EOF code 26 has been read (YES in step S209), it is determined

whether PF = 1 (step S210).

When PF = 1 (YES in step S210), it means that this frame is the final frame and therefore the processor 1 sets the power-down control signal PWDWN to 1 and changes the operation phase from the send phase to the receive phase (step S211). As described before, when PWDWN is set to 1, the IR device 6 is set to the power-down reset mode. Therefore, power is started supplying to the reception driver for driving the light-receiving device to operate the light-receiving function of the IR device 6. In the receive phase, the light-receiving function is needed. Thereafter, control exits from the frame check routine (step S212).

As described above, when operating in send phase, the receiving function is stopped. This allows power consumption to reduce without impairing the communication function. Therefore, the battery life built in a battery-powered portable information device can be increased.

power consumption reduce

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Another advantage can be obtained. Since the light-receiving function of the IR device is stopped during the send phase, a so-called echo-back canceling effect can be automatically achieved. In general, the light-emitting part is adjacent to the light-receiving part within an IR device. Therefore, the light emitted from the light-emitting device is partly incident back to the light-receiving device. To cancel such an echo-back component, the conventional communication

apparatus needs the echo-back canceling function in the IrDA stack program or the IR device. According to the present invention, there is no need to provide the IrDA stack program or the IR device with such a special function, resulting in simplified hardware and software configuration.

As a second embodiment of the present invention, the case of high data transmission rate at up to 1.152 Mbps or 4Mbps will be described hereafter. In this case, the synchronous serial interface is used.

In the synchronous serial interface, two different bit strings called STA and STO are used in place of BOF code 21 and EOF code 26 of the first embodiment. Further, in the case of data transmission at up to 1.152 Mbps, the escape code is not used to perform the transparent control. A bit is periodically inserted into data to be sent so as to discriminate between the data to be sent and STA and STO bit strings. In the case of higher data transmission rate at up to 4 Mbps, the same bit strings as the STA and STO cannot be used within data to be sent.

As shown in Fig. 7, in the second embodiment, a synchronous serial interface and a modem are incorporated in a single hardware circuit block 11. Other circuit blocks similar to those previously described with reference to Fig. 3 are denoted by the same reference numerals. This hardware circuit block 11 performs detection/addition of STA and STO and the transparent control. Therefore, the circuit block 11 outputs received data

from which STA and STO are deleted to the receive buffer 7 and receives sending data without STA and STO from the send buffer 8 through the send/receive handler.

Therefore, the same operations as shown in Figs. 5 and 6 can be applied to the second embodiment, provided that BOR- and EOF- related steps are replaced with STA- and STO-related steps in Figs. 5 and 6.

Each feature disclosed in this specification (which term includes the claims) and/or shown in the drawings may be incorporated in the invention independently of other disclosed and/or illustrated features.

Statements in this specification of the "objects of the invention" relate to preferred embodiments of the invention, but not necessarily to all embodiments of the invention falling within the claims.

The text of the abstract filed herewith is repeated here as part of the specification.

A data communication apparatus operable in half-duplex includes a transceiver, a detector for detecting an operation phase which is one of the send phase and the receive phase, and a controller controlling the transceiver such that the receiver is stopped functioning during the send phase.

Claims:

1. A data communication apparatus operable in half-duplex mode alternately switching between a send phase and a receive phase, comprising:

a transceiver including a transmitter and a receiver;

a detector for detecting an operation phase which is one of the send phase and the receive phase; and

a controller controlling the transceiver such that the receiver is stopped functioning during the send phase.

2. The data communication apparatus according to claim 1, wherein the controller controls the transceiver in communication such that the receiver is not driven during the send phase but during the receive phase.

3. The data communication apparatus according to claim 1 or 2, wherein, when the detector detects a phase switch signal from one of sending data and received data, the controller switches the operation mode between the send phase and the receive phase.

4. The data communication apparatus according to claim

3, wherein the phase switch signal is a poll/final (P/F) bit.

5. The data communication apparatus according to claim 1, wherein the detector comprises:

a first detector for detecting a received final frame from received frames which has been received by the receiver; and

a second detector for detecting a sending final frame from sending frames to be sent by the transmitter,

wherein the controller switches from the receive phase to the send phase when the first detector detects the received final frame and switches from the send phase to the receive phase when the second detector detects the sending final frame.

6. A data communication apparatus operable in half-duplex mode alternately switching between a send phase and a receive phase, comprising:

an optical transceiver including a light-emitting device and a light-receiving device;

a detector for detecting an identifier which is used to switch between the send phase and the receive phase; and

a controller controlling the optical transceiver such that the light-receiving device is not driven during the send phase.

7. The data communication apparatus according to claim 6, wherein the controller controls the optical transceiver in communication such that the light-receiving device is not supplied with power during the send phase but during the receive phase and the light-emitting device is not driven during the receive phase but during the send phase depending on sending data.

8. The data communication apparatus according to claim 6, wherein the light-emitting device and the light-receiving device are adjacent to each other in the optical transceiver to the extent that the light-receiving device receives part of light emitted from the light-emitting device.

9. The data communication apparatus according to claim 6, further comprising:

a send buffer for sequentially storing frames to be sent; and

a receive buffer for sequentially storing received frames,

wherein each of the frames to be sent and the received frames includes the identifier indicating whether the frame is a final one, wherein the controller switches from the receive phase to the send phase when the detector detects the

identifier indicating a final frame from the received frames and switches from the send phase to the receive phase when the detector detects the identifier indicating a final frame from the frames to be sent.

10. The data communication apparatus according to claim 9, wherein the identifier is a poll/final (P/F) bit.

11. A data communication method for exchanging data in half-duplex mode between a first terminal and a second terminal, comprising the steps of:

at the first terminal having a first transceiver,

sending frames of data to the second terminal with setting a receiving function of the first transceiver to power-down mode during a send phase;

switching the send phase to a receive phase when a final frame is sent to the second terminal;

receiving frames of data from the second terminal during the receive phase;

at the second terminal having a second transceiver,

receiving the frames of data from the first terminal during the receive phase;

switching the receive phase to the send phase when the final frame is received from the first terminal; and

sending frames of data to the first terminal with

setting a receiving function of the second transceiver to power-down mode during the send phase.

12. The data communication method according to claim 11, wherein each of the frames includes an identifier indicating whether the frame is a final one.

13. The data communication method according to claim 12, wherein the identifier is a poll/final (P/F) bit.

14. The data communication apparatus according to claim 1, wherein the transceiver is an infrared transceiver and the data communication apparatus operates in accordance with IrDA (Infrared Data Association) protocol.

15. The data communication apparatus according to claim 6, wherein the optical transceiver is an infrared transceiver and the data communication apparatus operates in accordance with IrDA (Infrared Data Association) protocol.

16. The data communication method according to claim 11, wherein the first and second transceivers are an infrared transceiver and the data is exchanged in accordance with IrDA (Infrared Data Association) protocol.

17. A data communication method or apparatus substantially as herein described with reference to the accompanying drawings.

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Claims searched: 1-17

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Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.R): H4B (BK10, BK22, BK24, BK24S), H4L (LECTP)

Int Cl (Ed.7): H04B: 1/44, 1/48, 10/22, 10/24, 10/28 H04Q: 7/32.

Other: Online: WPI, EPODOC, JAPIO.

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 2 180 424 A	(Shorrock Security) See especially fig.2 and page 12, lines 12-50.	1-3, 6, 7, 11, 14-16.
X	EP 0 759 666 A2	(Fujitsu) See especially the abstract, fig.4, and column 6, line 12, to column 7, line 15.	1-3, 6-8, 11, 14-16.
X	US 5 349 462	(Thomson-Csf.) See especially the abstract and figures 6 & 7.	1, 2, 6, 14, 15.
X	US 5 054 114	(Rockwell) See especially the abstract.	1
X	US 4 982 442	(Motorola) See especially the abstract.	1

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